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MINERALS FOR THE PHYSICAL GEOLOGY LABORATORY

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ABSTRACT. A list showing the frequency of citation of mineral species among 15 introductory geology textbooks and laboratory manuals is helpful in evaluating species used in the introductory course. Species low on this list should be selected only if they serve a definite purpose in the educational objectives of the course.

For several years I have introduced students to about 35 minerals in the physical geology laboratory course that I teach. Recently, in re-evaluating this assortment of minerals to see whether some other species might better suit the educational objectives of the course, I discovered two interesting things. One was that most of the species I was using had been used in the introductory course I had taken as an undergraduate. The other was that some of these minerals seem to be used rather rarely in introductory courses elsewhere. In short, I had unwittingly "inherited" many of the species from a generation of instructors whose educational objectives might have been somewhat different from my own.

At this point I thought it would help to know what minerals are generally regarded as basic, or most important, in an introductory study of geology. Assuming that frequency of citation is a fair guide to importance (or, rather, to opinions on importance), I tabulated the mineral species listed in 15 elementary geology textbooks and laboratory manuals.[1] The results are summarized in the list below. The numbers indicate the number of books in which the respective minerals (arranged alphabetically beside each number) are cited. In some books a distinction is made between important or common minerals and "other" minerals; in such cases I assigned one point each for the so-called important ones and only one-half point each for the others:

15 —biotite, calcite, hornblende (or amphibole group), muscovite, plagioclase feldspar, potash feldspar (or orthoclase), quartz.

14½—gypsum, halite.

14 —augite (or pyroxene group), hematite, magnetite, olivine.

13½—pyrite.

13 —dolomite, limonite (including goethite).

[1] See end of this paper for books consulted.

12½—garnet, kaolinite.
12 —galena.
11½—chalcopyrite.
11 —chlorite, sphalerite, talc.
10½—
10 —
9½—graphite, serpentine.
9 —
8½—fluorite.
8 —
7½—
7 —copper, chalcedony (including other microcrystalline varieties of quartz specifically listed), epidote.
6½—bauxite, staurolite.
6 —corundum, siderite.
5½—apatite.
5 —cassiterite, chalcocite, tourmaline.
4½—asbestos, malachite.
4 —anhydrite, azurite, barite, bornite, diamond, gold, topaz.
3½—
3 —ilmenite.
2½—actinolite, kyanite, sillimanite, sulphur, uraninite (or pitchblende).
2 —cinnabar, coal [!], glauconite, ice, zeolite.
1½—andalusite, arsenopyrite, beryl, carnotite, molybdenite, nepheline, pyrolusite, silver, wollastonite.
1 —celestite, chromite, clay [?], cuprite, leucite, magnesite, marcasite, obsidian [!], opal, ottrelite, sericite, stibnite, tremolite, zincite.
½—brass [!], lepidolite, orpiment, petroleum [!], psilomelane, pyrrhotite, realgar.

Textbooks and laboratory manuals are generally better guides to what is being and has been taught than to what could or should be taught, for they too have inherited much from previous generations. Even allowing for this, however, the solidarity of the first seven, or even the first thirteen, minerals in the list is noteworthy, as is the gap between talc (11) and graphite (9½).

In revising my own selection of minerals, I have assumed that those at the top of this list are basic, and should form the nucleus of any selection of minerals used in the introductory physical geology laboratory. Those at the bottom, in contrast, should be used only if warranted by special objectives. Other instructors may prefer to interpret this list as a rough scale of mineral popularity rather than of mineral importance. But whatever its significance or shortcomings, it does provide an initial, if arbitrary, basis for evaluating minerals used in the introductory course.

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STUDENT TRAINING FOR A SUMMER FIELD COURSE

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ABSTRACT. Poor performance by potentially capable students during a summer field course in geologic mapping usually results from inadequate background in basic geology. Proper training to prepare for mapping should instill facts and principles, the use of three-dimensional visualization, and an acquaintance with the scientific method. Initial weakness in fundamentals lessens a student's accomplishments in structural interpretation, a primary objective of a mapping course. In light of this, some geology teachers would do well to reappraise their major program.

INTRODUCTION

Certain weaknesses in the geologic background of many students become apparent during the advanced field course in geologic mapping offered by the University of Wyoming in co-operation with Columbia University. Some 2,000 students, from more than 100 different institutions in all parts of the United States, have taken field courses in geology at the Wyoming Summer Science Camp during the past 37 years. The largest number of students is from Wyoming and Columbia universities, but a substantial number, 20 to 30 each year, of selected students are from 20 or more other schools, mostly liberal-arts colleges. The faculties of Wyoming and Columbia provide most of the instructional staff, and as a result they have had continuing opportunity to evaluate students' classroom teaching by observing student performance in the field. The following opinions, based on ten years of personal experience, are directed mainly to those geology teachers who have not had such an opportunity.

The course consists of five one-week exercises. The first includes measuring and describing in detail a stratigraphic section as a basis for later exercises, a short project in pace-and-compass mapping, and field trips to demonstrate local geology. The other four exercises are devoted to structural mapping, using successively a topographic contour map, plane table and alidade, and aerial photographs. The map areas are of increasing structural complexity; three are in sedimentary rocks and one in metamorphic and igneous rocks. Each week, students devote Monday through Friday to field work and Saturday to the office work needed to complete the exercise. Prompt correction and discussion of each exercise by the instructors allows each student to correct his errors while the course progresses. Student interest remains high because of the variety of exercises and because a poor performance one week need not affect the next week's work.

The main objectives of the course are training in a variety of mapping techniques, and training in interpretation of geologic structure based on mapping and the construction of cross-sections. Lack of previous training in techniques does not

seriously hamper a student, because these can be learned during the course. Inadequate background in basic geology, however, is a serious handicap. Another objective is to give the student the experience of being a practicing geologist. He can apply his academic training to the realities of the field, where relations are seldom as obvious as those illustrated in the classroom. Also, he can discover whether his aptitudes and personal make-up are suitable for a career in geology. The summer mapping course is designed neither as a pleasant dude-ranch experience nor as good remedial work for incompetents, although it may provide elements of both. Rather, it is a training ground for prospective professional geologists, who, as things stand today, may soon face stiff competition in a declining job market.

Acceptable mapping, I think, requires a modest store of usable geologic knowledge, some understanding of maps, ability to visualize space relations in three dimensions, and proper application of the scientific method. Poor training in any of these areas handicaps a student regardless of his intelligence.

ELEMENTARY REQUIREMENTS

A student must have usable information from several of the traditional fields of geology before he starts a mapping course. Unfortunately, a college transcript attesting that a student received grades of "B" or better in general geology, mineralogy, lithology, geomorphology, or structural geology is no guarantee that he has retained much that he can apply. On the outcrop, a student must be able to recognize common minerals and rock textures in order to identify the common rocks; have some appreciation of topography as a clue to earth materials and structures; and know a few simple criteria for faulting and the attitude of bedding. He must also know simple mathematics. This knowledge must be available in a student's head. Knowing which books to look things up in, although a necessary part of education, is unfortunately no help in the field. To give a student the necessary competence in these subjects requires neither major slanting of existing courses nor the introduction of special courses in the traditional geologic curriculum. In most instances, a more demanding attitude on the part of geology professors in classroom and laboratory would secure the desired results.

Student weaknesses in the understanding and use of maps suggest that many individuals entering the field course have had little or no effective contact with topographic or geologic maps. As maps are essential to proper teaching of various aspects of general geology, geomorphology, and structural geology, it is surprising that students do not have more facility with them.

Many students have difficulty locating themselves with topographic maps, or even with aerial photographs. Happily, we have never lost a student during the course, but on not a few occasions individuals armed with Brunton compass and maps or photos have wasted several hours "mis-oriented" in mapping areas of one or two square miles, moderate relief, and little forest cover.

Mislocation of contacts or structural symbols plotted on a base map is a common error. This may result from a poor sense of scale relations, inattention to topographic detail, or both. The main trouble students commonly have with scale does

not stem from lack of knowing a classroom definition but from inability to estimate actual ground distances. An outcrop more than 1000 feet from a prominent topographic feature may be thought to be less than 500 feet, and so plotted on the map. In plane table work, students are sometimes encountered rodding geology well beyond the limits of the plane-table sheet.

The relation of actual topography to the minor "bumps and squiggles" of good contour maps is not appreciated by many students. Unless the topographic feature depicted is very obvious, it is not recognized and used as a control in plotting on the map. To help prepare a student for a mapping course, serious attention should be given to determining location, and to map and ground distances, in laboratory work or field trips during the regular school year.

THREE-DIMENSIONAL VISUALIZATION

Too few students realize that a geologic map is a two-dimensional projection of solid geometry involving rock masses and topography. This shows up in a number of ways. Some students, early in the field course, think that the map width of an outcrop should be the same as the thickness of the unit mapped. Many are surprised that a thin limestone forming the dip-slope of a hogback could have appreciable width on the map, or that a thick formation in the steep front of a mesa should be narrow on the map. They are frequently not aware of the effect of topography on the trace of fault or formational contacts. A simple case of this is in the drawing of straight contact lines to represent a flaring gap through a hogback ridge.

The "wiener" contact also illustrates a lack of three-dimensional thinking. In this case, students draw sausage-shaped or elliptical patterns to represent the outcrop of a continuous formation dipping more steeply than the slope of the topography. They fail to realize that such a unit should be mapped as continuous, even if bedrock is not always cleanly exposed, or else that it should be "tied off" against an unconformity, a fault trace, or the margin of the map. Other illustrations could have been chosen relating to recognition of overturned beds and the general use of geologic symbols to clarify structural relations.

Three-dimensional visualization is not easily taught because so much depends upon a person's natural ability; yet much can be done that will prepare him for the field. Where possible, block diagrams should be used in classroom presentation. Exposure to the details of good geologic maps, interpretation of unfinished structural block diagrams, construction of cross-sections from geologic maps, and the making of geologic maps by interpretation of topographic maps or air photos, are invaluable in preparing a student for three-dimensional thinking in the field.

SCIENTIFIC METHOD

The preparation of a geologic map in the field should be a nice exercise in the scientific method. The problem is clear: to interpret the structure of an area. Facts are accumulated in the form of dips and strikes, lithologic descriptions, and contact relations. A structural hypothesis, relating the facts, is created through induction and imagination to give direction to the work. Testing and prediction by deduction

of expectable observations can be used to check interpretations in areas already investigated and to aid in extending map coverage. Admittedly, this oversimplifies a method that is no guarantee of 100% success; but students who operate in this manner are the most successful mappers. A few may do so intuitively, but all would benefit from some previous introduction to the thinking and procedures involved. Several common weaknesses of student mappers show lack of training in the various aspects of a scientific approach.

The need for careful observation is not appreciated by many student mappers. Some seem oblivious or scornful of detail, either from lack of training in careful observation or in the belief that all detail is trivial. For example, some students learn the hard way that structural mapping in areas of any complexity is frustrating if one has not previously mastered the lithologic details of the formations involved. If two quartz sandstones in a normal stratigraphic section are separated by a 1500-foot interval containing several formations of different appearances, there seems to be little need to bear down on the fine details of the two. Yet in mapping a deformed area, it may be imperative to know which of the sandstones crops out in a small exposure surrounded by soil and vegetation. Here, detailed lithology may be the only clue to the existence of a major fault in the area. A student can be trained to observe carefully, and almost any laboratory work should have this objective. A few exercises in carefully written, detailed descriptions of hand specimens might save the prospective mapper from unnecessary difficulties in the field.

Often students do not realize that inference is involved in scientific method and is necessary in bedrock mapping. Perhaps this stems from the mistaken notion that science deals only with certainty. In any case, a geologic structural map is not just a plan view showing the location of scattered patches of bedrock projecting through soil. After all, a bright high-school student could be taught to locate and plot such patches after a brief indoctrination in the local rocks; but it takes a geologist to interpret the observations and compile them into a logical structural map. It is advisable to be cautious and indicate contacts as inferred where necessary, but this does not eliminate the need to plot contacts beyond the limits of the actual exposure of bedrock. A classroom introduction to the use of inference is possible through assignments requiring the completion of a structural map from an incomplete map showing scattered outcrops and contacts with a few significant dip and strike symbols.

Many students dot not use working hypotheses in the field. They may not know there are such things, or may not make use of the inference and three-dimensional visualization needed to create them. Hard-working individuals often cannot understand why they map so slowly with no particular gain in accuracy. They never "waste" time on hilltops looking for broader structural relations. Instead, they wander around engrossed in observing details which they never relate to a broad pattern. After mapping one part of an assigned area, they move to a nearby part and start working that as if it were totally unrelated to what they have already done. No attempt is made to predict the locations and attitudes of the probable formations they may expect to encounter.

Some compound their difficulties by refusing to map as they go. They cover much ground but have little information plotted to show for their efforts. As a result, time is lost because they almost certainly have to revisit the ground in order to complete an accurate map. More important, this procedure hinders the creation of working hypotheses which might become evident once the student sees his map developing on paper. In contrast, the effective mapper, after plotting the necessary contacts and dips and strikes, makes an assumption: for example, that he is mapping an asymmetric anticline trending northeast. Using this hypothesis, he can plan his traverses to observe the most significant outcrops in a minimum of time. Further observations may verify his original concept. Even if they cause its rejection, they give direction to his work.

How to train an individual to develop sound working hypotheses, I do not know. An undergraduate having a minimum background in geology may have a fair grasp of the general structural pattern in a mapping area after the first day's work; a graduate student having many course credits in geology may not visualize the over-all pattern when the week's exercise is finished. Bluntly, some have it and some don't. However, classroom training can alert a student to the place and need for creative thinking and imagination in geology, and allow him to try his own. The completion of incomplete block diagrams and maps, previously mentioned, might be an approach to this problem. Certainly a student who is completely ignorant of the logic behind geology is handicapped in an advanced field-mapping course. He must realize that geologic investigation should be based on facts, but it is not a mere matter of collecting random data.

CONCLUSIONS

A summer field course offers the ideal situation for teaching most of the aspects of geology that have been discussed. By the end of the course, I think that all students make considerable progress. Whether this results mainly from superior instruction or simply from exposure to excellent map areas, I am not able to say. A number of individuals have ended the course as excellent student mappers despite weakness or lack of training in everything previously mentioned; but they are the memorable exceptions. Generally students with a good background in the matters mentioned make the most progress throughout the course. They have a marked advantage because they need not learn fundamentals in the field, and therefore can concentrate on mapping and structural interpretation.

Poor preparation of students for a summer mapping course implies weakness in their whole geologic program. Successful work in the course requires previous mastery of facts and principles from lectures and textbooks, otherwise the student in the field has the difficult task of creating for himself the essential mapping knowledge accummulated by geologists from the time of "Strata" Smith to the present. Even more necessary are the abilities to observe, visualize, and make reasonable geologic conclusions. These are probably best taught in courses where the student must actively participate rather than passively scribble notes for later memorization and written regurgitation. Structural mapping, although only a part of geology, contributes in very large measure to general geologic training.

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AN INTEGRATED FINAL EXAMINATION FOR LABORATORIES IN INTRODUCTORY GEOLOGY

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ABSTRACT. A huge geologic map is drawn on the floor of the laboratory or on a suitable surface outdoors. Specimens of rocks, minerals, and fossils representative of the geologic formations depicted are placed between contacts. Students, walking on the field area, "do" the geology by reproducing the outcrop pattern at an appropriate scale and labeling their maps according to rock, mineral, and fossil identifications. Geologic sections are then prepared from the completed map and a geologic history (in terse, outline form) is given. The interdependence of all phases of laboratory work is shown very realistically in this way.

One of the most important lessons to be learned by the geology student is the intimate interdependence of the various branches of geology in the solution of any geologic problem. For example, in order to "do" the geology of a given region it is necessary to relate outcrop pattern to mineralogy, petrography, structure, and stratigraphy. Stratigraphy, in turn, may depend on paleontologic succession and perhaps on facies changes as well. Only after all such available evidence has been harmonized can a reasonable picture of geologic history be drawn.

With this in mind a final laboratory examination has been designed for use in the Introductory Geology course at Washington State University. This test illustrates the importance of rock, mineral, and fossil identification in geologic mapping and historical geology. Moreover, it gives the student a feeling of confidence in his ability to "do" the geology of an area in a manner commensurate with his background. It also develops an appreciation of the problems of field geology.

A modified form of the exam has already been given in the laboratories at Washington State. It was received exceedingly well by students and instructors alike, and left the students with a strong feeling of accomplishment. It is felt that this type of test can be adapted by most geology departments despite differences in size, equipment, and student body.

The idea for the examination probably germinated in the halls of the Mining Geology Building at Harvard. There the author first saw Professor Hugh McKinstry's students struggling with strange outcrops chalked on the walls, floors, and ceiling. Apparently this tradition has been continued for years and in those dimly lit corridors the resemblance to actual underground mapping is uncanny. Why not, it was decided, have a similar mapping exercise in surface geology? In fact, why not give lab finals in introductory geology on a football field, golf course, parking lot, or some other large expanse of ground susceptible to marking?

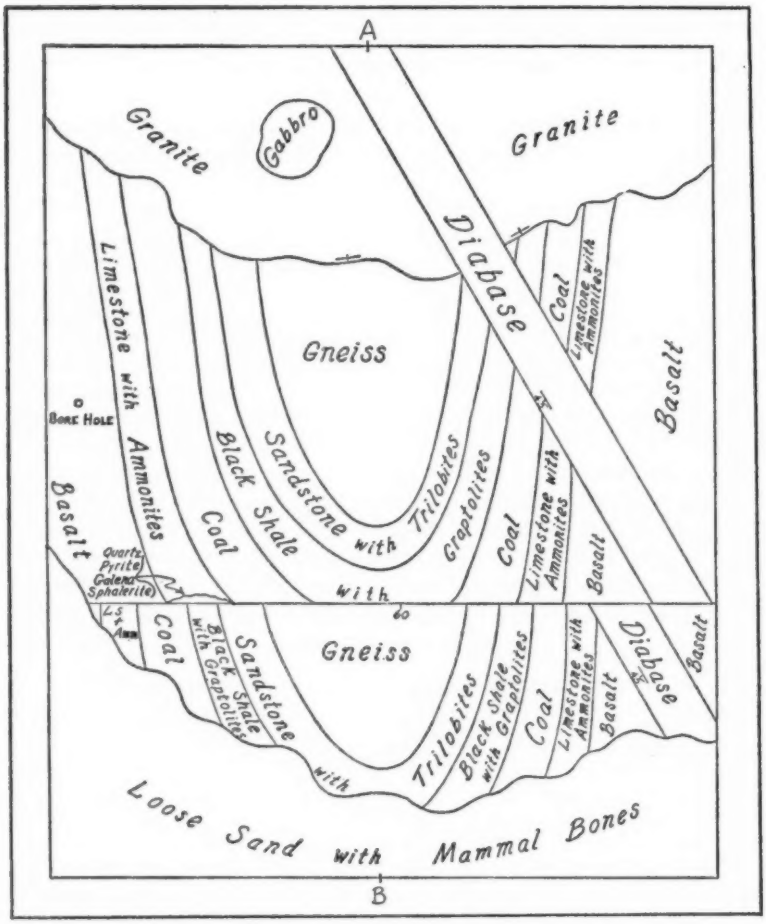

FIG. 1. Plan of a typical field area. Contacts are marked on the ground. Specimens of the rocks named are displayed on boards placed within the proper outcrops. The student's finished map should look essentially like this, and should also include a scale and a north arrow.

Plans were made for such an exam at Washington State University, but it was first decided to try the idea on the floors of the laboratories. In essence this trial was only a modification in scale of its large-size counterpart. Unbeknownst to the writer, somewhat similar exercises had been set up on the floors and furniture of laboratories at M.I.T. (Dennen, 1954). However, the Washington State exam has significant differences in method and purpose which separate it from other known tests. The following description refers to the large-scale outdoor version, but can apply, with appropriate modification, to an indoor exam as well.

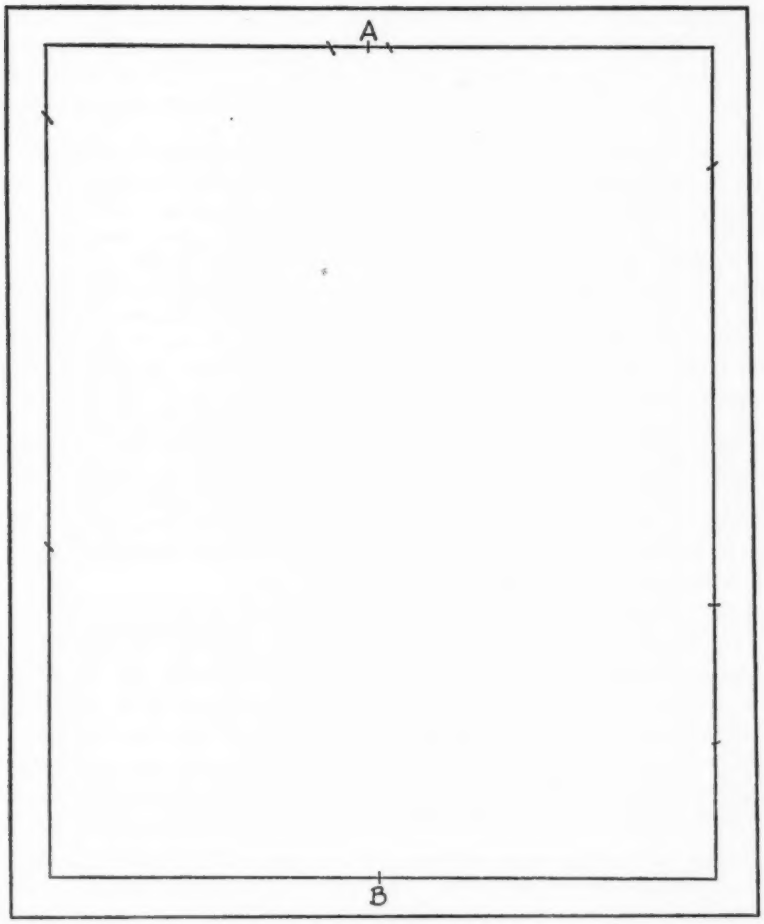

FIG. 2. Base map of field area showing intersection of contacts with border of map area. Such a base may be furnished in order to help beginning students start their mapping. It also insures accurate location of the structure section, A-B.

Outcrop patterns should be laid out between definite boundaries on an extensive surface such as an athletic field, golf course, lawn or parking lot. If the surface is grassy, a chalk line marker (available through most athletic departments) can be used. Chalk or removable paint can be applied to hard surfaces. In effect a huge geologic map is drawn (Fig. 1) showing a neat border surrounding all faults and lithologic contacts. It may be advisable to prepare a mimeographed base map for the student, showing (to some appropriate scale) the border of this field area. Such a base map might also show tick marks at the intersection of contacts and map border (Fig. 2).

Selected rocks, minerals, and fossils are placed within the outcrops as shown by Fig 1. In order to facilitate location of these specimens they can be displayed on conspicuous boards along with any necessary written directions. Thus their position is fixed and they will be returned to the same place each time they are handled. Bore holes are marked on the map area and are located by a sign or a flag. Bore-hole records are displayed nearby. The attitudes of certain rock contacts (e.g., intrusive bodies), as well as faults and unconformities, can be shown by placing boards (with the appropriate strike and dip) in the ground along the contact.

As part of the exercise the student should be required to place a north arrow and an appropriate scale on his map. Scale can be estimated by inspection or by pacing the map area. It should be shown both graphically and as a representative fraction. North can be read from a compass in the field. It can be shown approximately on the map as true north and magnetic north separated by the correct magnetic declination.

Students should be advised to follow outcrops and their contacts during mapping. Specimens may be identified while walking out outcrops or after the outcrop pattern is drawn. Identification should be shown within the proper outcrop on the final map. It may also be advisable to discourage students from taking vantage points in nearby trees, bleachers, or buildings in order to do "photogeology." This could give an unfair advantage to the nimble.

After mapping and identification of specimens is complete, the student should draw a specified structure section (A-B on the map). This should be along a line of traverse designated in the map area by flags or signs (which may be connected with a string). For greatest accuracy the structure section should be drawn at the scale of the map. All bore-hole records and data on strike and dip should be considered in its construction. If the problem demands it, some relief can be shown on the structure section (e.g., a lava flow resting on the eroded edges of folded strata might best be shown by giving the structure section a little relief at that location).

Finally the student should write a brief geologic history of the map area in terms of a simple sequence of events. For example, the geologic history of Fig. 1 could read:

1) Emplacement of rock that became gneiss.
2) Metamorphism to gneiss.
3) Erosion of gneiss.
4) Deposition of trilobitic sandstone.
5) Deposition of graptolitic black shale.
6) Deposition of plant material—beginning of coal-forming processes.
7) Deposition of ammonitic limestone.
8) Eruption of basalt.
9) Folding (accompanied and succeeded by erosion).
10) Intrusion of granite (with inclusion of pre-existing gabbro or later intrusion of gabbro).

11) Intrusion of diabase dike.
12) Reverse faulting with mineralization along fault.
13) Erosion (starts with (12)).
14) Deposition of loose sand with mammal bones.

Students at Washington State are told at the beginning of the course that they will need to grasp all aspects of the lab work in order to solve the problems of the lab final. As soon as it can be appreciated, the exam is described. This gives additional incentive to study rocks, minerals, fossils, and structures throughout the term. Furthermore, a "dry run" exam is given a week before the final to break students in to the process of walking outcrops and transposing information to a geologic map. Considerable confidence is gained after such a trial and the final doesn't come as a shock.

It is obvious that in such a test the correct completion of one part depends on the results of preceding phases. Thus, the structure might be misinterpreted if rock, mineral, and fossil identifications are not correct. Moreover, such identifications and the interpretation of structure affect geologic history. Therefore, grading the interrelated parts requires judgment. For example, some credit should be given a student who followed through in later parts of the test by reasoning logically from an early misidentification.

At Washington State the lab finals are graded on the following basis:

40% for identification.
25% for geologic structure.
25% for geologic history.
10% for north arrow, scale, and neatness in mapping.

While this final examination brings together many of the subjects of an introductory course, it fails to test ability to interpret topographic maps. However, we are satisfied to give topographic map exams earlier in the term, in order to wind up with a final that is comprehensive, integrated, and a satisfaction to the student.

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NEW MAPS FOR TEACHING TOPOGRAPHIC-MAP INTERPRETATION

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ABSTRACT. As the uses of topographic-map interpretation become more widespread, not only in geology but in such new fields as "terrain science," a re-examination may well be made of teaching objectives, methods, and materials. Several levels of instruction are involved: recognition of individual landforms, understanding of landscape associations, and techniques of quantitative expression and analysis. The rapidly increasing number of topographic maps makes desirable the compilation of carefully selected up-to-date lists to supplement the familiar lists in standard texts on map interpretation. This is too great a task for an individual teacher, but it could be done by cooperative effort under sponsorship of the N.A.G.T.

As topographic maps are being produced in increasing numbers, types, and scales in the United States and throughout much of the world, map interpretation is becoming correspondingly more important, not only in geology but also in related subjects. Map interpretation is particularly valuable in the development of such new fields as "terrain science," which seeks to understand the total expression of the earth's surface in bedrock geology, topography, soils, vegetation, climate, etc. (Betz and Elias, 1957). With the increasing opportunity for using topographic maps and the broadening of application of these uses, it is appropriate to reexamine the objectives, methods, and materials of teaching map interpretation. Topographic maps are ideally suited to introduce the beginning student to three-dimensional features shown on a plane surface. Competence in the use of topographic maps is necessary for the mastery of more sophisticated expressions of geologic and other specialized maps and of aerial photographs.

The degree of mastery of topographic maps is proportional not only to the time available for study but also to the success of the teacher in planning a sequence from the basic mechanics of map reading through elementary identification of landforms to full exploitation of all available map information. In beginning courses, training in the mechanics of map reading is commonly followed by practice in visualizing from contours such common forms as hills, valleys, scarps, and depressions. Examples used at this level are well developed and uncomplicated, for identification is made wholly by recognition of individual features with which the student has become acquainted in his study of landforms. The next stage usually consists of studying maps that show landforms in different stages of development, or in different climatic and tectonic environments. The student thus learns to consider land features in terms of their locale and associated features. As he gains proficiency, features of ambiguous origin or identity are included, for an important step in map interpretation is the realization that the map may not provide a single

answer, and that, unless other evidence is found, multiple or alternate hypotheses must be accepted. (Through ambiguous examples the teacher has an excellent opportunity to develop and test the student's power of observation, and to guide and judge his ability to weigh evidence in determining an explanation for a given problem.)

Other techniques of map analysis are sometimes presented, e.g., profiles, projected profiles, and slope analyses, along with some of the more recent techniques of quantitative expression of areas, volumes, stream densities, and drainage-basin characteristics. Throughout, every effort is made to improve the student's ability to observe detail. With such graduated experience, he should be well prepared to use fully all information available on topographic maps.

MANY NEW MAPS AVAILABLE

Some 50 years ago, Salisbury and Atwood (1908) compiled a large volume designed to introduce the novice to reading and interpreting topographic and geologic maps. At that time, only about 1800 topographic maps and 110 geologic folios had been published by the U. S. Geological Survey. Since then, as the number of topographic maps has steadily increased, and their use as a medium of expression of geologic features has become a vital part of teaching, other texts have been published, e.g., Dake and Brown (1925), Lobeck and Tellington (1944), and Putnam (1943). Briefer coverage is included in general texts and field manuals, and the number of laboratory manuals is steadily growing. Yet the list of maps included for study has changed surprisingly little over the years. Although the early map selections are fine examples of the mapmaker's art and of the geologic features and processes depicted, repetition has tended to cause stagnation in map usage, and perhaps a certain dulling of enthusiasm in the teacher. With the number of new topographic maps that become available through the U. S. Geological Survey alone now exceeding 1500 per year, there is an excellent opportunity for inclusion of a greater variety of maps for teaching.

Maps of varied scales and designs. Often, maps of a single area are available in varied scales, contour intervals, and cartographic expressions. These variations can be used to advantage in demonstrating the mechanics of map reading, at the same time showing the values and limitations of each design. Landforms can be shown in detail on large-scale maps, and in their regional setting on small-scale maps. Different methods of showing relief can be studied—e.g., contour and shaded-relief maps of such national parks as the Tetons and the Great Smokies; or the recent U. S. Geological Survey reconnaissance maps of Arabia, which show relief by plastic shading alone. Planimetric maps aid in pointing out the advantage of contours and other relief expression, and also in demonstrating the amount of information on relief that can be gleaned indirectly from a careful study of drainage and culture.

Editions. Successive editions of many maps may be used to demonstrate the cartographer's problem of keeping information up to date, especially where there are rapid changes in cultural detail. More important, varied editions often illustrate

geologic phenomena in action: sets of Swiss maps show changes in position of the ice borders; Mississippi River maps show changes in its course; maps of areas of large-scale strip mining, reservoirs, etc., show man-made changes.

Landforms. Maps showing various landforms can be selected to satisfy the different levels of student experience. Many fine examples of general topographic forms are found in the recent collection of maps compiled by the U. S. Geological Survey for teaching purposes (Upton, 1955). Maps illustrating landforms of a particular type require careful selection, so as to show ideal expression, stage of development, associated features, and varied environments. Whenever possible, such maps should be representative of major physiographic provinces, for then the identity of a particular geologic feature or process may be related to its regional setting. Some of the national park maps offer fine representations of various physiographic provinces, as well as outstanding examples of geologic phenomena. These maps have the added advantage of showing areas that the teacher and/or student may have visited, and literature describing the geologic details is usually easily available.

Foreign maps. Foreign topographic maps offer a relatively untapped source of teaching material. The added effort necessary to obtain them is well compensated. Not only do they offer an opportunity for study of a variety of map designs, but, more fundamental for the student of geology, they serve to demonstrate the universality of geologic processes. Foreign maps also provide better examples of some features than are available on domestic maps. For example, Alpine glaciation in this country is illustrated solely by such maps as the Mt. Lyell and Mt. Whitney quadrangles showing small remnant glaciers—maps which, though beautifully made, do not show detail comparable to that of the larger-scale maps of the Swiss and French Alps. Some of the Swiss and French maps are among the finest examples of the mapmaker's art. The wealth of detail offered, the variety of expression, and the opportunity for the student to compare foreign and familiar American examples of landforms, make the use of foreign maps a stimulating experience.

Teacher's choice. Of course the teacher's experience should be a prime factor in map selection. Whenever features to be studied are included on maps of areas with which the teacher is familiar, he should certainly select those maps for use, especially in class discussion. One is often at some disadvantage in describing an area which he has not seen, whereas the opportunity to discuss one with which he is familiar allows him to bring that area alive. Such exploitation of personal experience is one of the chief advantages of preparing individual laboratory manuals or exercises.

SELECTING NEW MAPS

Personal selection of maps for use in elementary geology and introductory map-interpretation courses is easily done. Material for use in advanced work, often requiring "sets" of maps, is more difficult to accumulate. To compile map lists for varied geologic topics may involve going through thousands of maps, which is so time-consuming a task that the beginning teacher, at least, is forced to go back to the lists in the old manuals, Dake and Brown, and Professional Paper 60. Also,

since the map collections of many departments are limited, even if the instructor has the time to compile new lists he may lack the facilities.

Although the task of evaluating all possibilities and keeping up to date is too great for one person to accomplish, it might be undertaken through cooperative effort. The National Association of Geology Teachers is organized in sections in many parts of the country. Sectional committees could be formed to compile lists of new maps for the state or states represented in the section. A special committee, composed of members having access to large map libraries, could make selections of foreign maps. These lists, made under headings previously agreed upon, with specialized subheads where local conditions warrant, could then be published for general use.

The above plan would result in a publication similar to the list of aerial photographs published by the American Geological Institute. If interest warrants, a continuing committee could review map additions each year and offer supplements to the general report. Such lists would be of great service to new teachers, especially in small schools and in new departments where map collections are limited.

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CONSTRUCTION AND USE OF AN INEXPENSIVE CONTROLLED PHOTOMOSAIC FOR GEOLOGIC MAPPING

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ABSTRACT. A method is described for constructing an inexpensive controlled photomosaic of an area having vertical aerial photographic coverage. The mosaic is used as a base map for geologic mapping where an adequate planimetric map is lacking. Distortions in the aerial photographs are reduced or eliminated by projecting the images of points on the photographs so that they coincide with corresponding points on a control sheet mounted on a tilting easel. The control sheet is prepared by photo triangulation, with or without additional ground survey control. The corrected image is reproduced on photographic paper and the prints combined to make a controlled photomosaic. Geologic data recorded on aerial photographs can be transferred easily and quickly to the mosaic and thence to a transparent overlay sheet for reproduction.

Introduction

The purpose of this paper is to describe a method of preparing a detailed base map for geologic mapping of areas having vertical aerial photographic coverage but lacking an adequate planimetric base map. Although contact prints of vertical aerial photographs provide an excellent base on which to plot geology rapidly and in detail, they are not map projections but conical projections. Maps prepared directly from them retain the distortions inherent in the photographs. The methods employed by photogrammetrists to reduce or eliminate these distortions require elaborate equipment and high technical skill not often at the disposal of geologists. The present paper indicates an inexpensive and convenient way to reduce these distortions. Geology students anticipating field mapping in connection with their thesis problems may find it valuable.

Photo Data Transfer

A person using aerial photographs should familiarize himself with their characteristics and learn something of the problems in their making and use. Two books written for and by geologists, Low (1952) and Eardley (1942), serve very well to acquaint the student geologist with the elements of aerial photography and its role in geologic mapping.

Three conventional ways by which mapping detail may be transferred, with simple equipment, from the photographs to the base map are (1) triangular division, (2) vertical sketchmaster, (3) photomosaic. The triangular division method consists of dividing the total area of the photograph into a number of small triangular units corresponding to similar, but not identical, divisions of the map. Photo details are sketched on the map according to their relative positions within the small unit

subdvisions. The sketchmaster method of transferring data from aerial photographs to a planimetric map is referred to by Lahee (1952); it is familiar to most geologists and needs no elaboration here.

Each of these two methods has one or more serious drawbacks. The triangular division method requires that there be a virtual maze of points and lines on the base map and on the field photographs (or their transparent overlays) when mapping is detailed. The sketchmaster method, though more precise, poses difficulties that have to be experienced to be appreciated. The instrument adjustments are basically elementary; but if the photographs have more than a little distortion, the essentially trial-and-error procedure for correcting the distortions can be very frustrating. The difficulty in securing adequate illumination and the inordinate length of time spent hunched over this device, in order to transfer even a small amount of detail, lend nothing to its attractiveness. It may be that the case against the sketchmaster has been overstated, but the fact that geology field-camp students refer to the instrument by such terms as "three-legged monster" and worse would indicate that the method leaves much to be desired.

The third method of transfer is the one advocated in this paper. It involves the use of a photomosaic in lieu of a conventional planimetric base map. Data plotted on contact prints in the field are transferred to the photomosaic in the office by reference to photo detail. Although the preparation of a photomosaic is a time-consuming operation, an important point to keep in mind is that a mosaic may be prepared at the geologist's convenience, before going into the field. Field time then can be spent profitably in mapping and writing, with only an insignificant share devoted to transfer of mapping data to the base map.

Low (1952) and Eardley (1942) describe the steps to be taken in the preparation of an uncontrolled photomosaic. An uncontrolled mosaic is prepared directly from aerial photographs and retains the distortions inherent in the photographs. Mosaics prepared with extensive surveyed ground-control points and rectified prints are called controlled mosaics (Low, 1952, p. 235). They make excellent base maps, but their execution ordinarily requires highly skilled technical help and elaborate equipment. However, an inexpensive controlled photomosaic may be prepared with little technical skill by the method described below in which a minimum of ground control is used, such as may be supplied by State Highway Department maps. Although the resulting mosaic is no match for a professionally prepared controlled mosaic, it is sufficiently accurate in scale and azimuth for all mapping on 1:20,000 scale vertical aerial photographs.

Preparation of the controlled photomosaic includes (1) making a control sheet, (2) correcting the distortions in the contact prints (photo restitution), and (3) preparation of the mosaic.

CONTROL SHEET

The largest distortions in photographs are introduced by variations in the flying height, angle of tilt (deviation of the optic axis from the vertical), and topographic relief. The first two may be disregarded since they are kept at a minimum

in modern aerial photography; the distortions resulting from them are within the limits of error of the geologic mapping. Variations in topographic relief, however, may introduce distortions (displacements) of considerable magnitude; these have to be corrected. Low (1952) and Eardley (1942) describe a means, the "radial line method," of making the corrections in the displacements due to topographic relief. According to Eardley (1942, p. 55), "the radial line method takes its name from the principle of radial displacements and implies that if radial lines are drawn from the principal points of two overlapping photographs in a flight strip to a common image in the field of overlap, the intersection of the lines will determine the true position of the image."

The first step in correcting the displacements due to topographic relief is to plot and transpose on each photograph all principal points (photo centers in vertical photographs) and all secondary points in the overlap area of neighboring prints (Low, 1952, p. 269-270). The second step is to prepare strip plots (Eardley, 1942, p. 56-63) on transparent overlay material. Acetate film or any one of the new stable transparent plastic materials make quite satisfactory overlays. Strip plots are matched and joined together. On them are shown all principal and secondary points, numbered in ink for ready reference. The points are now in proper relation to each other despite differences in relief of their corresponding ground points. The tracing assumes the scale of the photographs.

Should control points be available from existing maps, plane-table surveys, or other source, then a more accurate map can be prepared by redrawing the strip-plot map on a new overlay sheet. This is done by first plotting the control points on some convenient scale, then plotting the rest of the photo points by reference to the first strip-plot map, in their proper position with respect to the control points and to each other. The finished control sheet or map is more accurate than the one without survey control, and it has the further advantage that it is on some convenient scale, rather than the arbitrary scale of the photographs.

An alternative method of compiling a control sheet, when control points are available, has been described by Low (1952, p. 270-274). By this method the control points are employed to position the photo points correctly at the start and hence there is no need to redraw the strip plot map.

PHOTO RESTITUTION

The first step is to photo-copy each of the aerial photographs with its principal and secondary control points. Although photo-copying is described adequately in photo handbooks on sale at camera stores, acceptable results can be obtained by an amateur without outside help of any kind by following the procedures outlined here.

Each vertical photograph is fastened to a wall and illuminated evenly by two photoflood lamps in reflectors inclined about 45 degrees to the photograph. The uniformity of illumination over the material to be copied is checked with a light meter. A tripod-mounted camera, with its optic axis 90 degrees to the photograph, is focused on the photograph. A camera with an extension bellows is probably the most convenient to use since it requires no accessory lenses. However, the author

used a 2¼ by 2¼ reflex camera and an accessory "close-up" lens. This lens is placed over the camera viewing lens during focusing and over the "taking" lens when the exposure is made. Camera lens aperture is kept small so as to give a reasonable depth of field. Reflected-light meter readings are taken from the photograph and a normal exposure time determined for the type of film used (Kodak Panatomic X). The actual exposure time given, however, is only one quarter of that determined by meter.[1] The film is developed not in a film developer but in a paper developer (Kodak Dektol diluted 1:1) at 68 degrees Fahrenheit, for 10 minutes rather than the 4 minutes recommended by the manufacturer.[2] The film is fixed, washed and dried in the usual manner.

Each negative is mounted in a condenser enlarger (Omega) and its image projected to an easel that can be tilted. A plane table and Johnson-head tripod serve very well as a tilting easel. The control sheet prepared earlier is placed on the plane table. The table then is tilted until the images of any three adjacent negative points (principal or secondary control points) coincide exactly with the corresponding three points on the control sheet. A sheet of single-weight glossy (Kodabromide) photographic paper, slightly larger than the area between the three points, is then substituted for the control sheet and exposed. This process is repeated for each triangular area outlined on each negative by three adjacent points. The number of triangular prints may vary from fifteen to twenty-five for each aerial photograph of a stereo pair depending upon the number of control points. The small paper prints are developed (Kodak Dektol), fixed, and dried between clean photo blotters or towels. Note that the prints are not dried on ferrotype plates in the conventional fashion because this gives the prints such a high lustre that they do not take ink well. Semi-matte photographic paper takes ink and pencil well, but it does not register quite as much photo detail as glossy paper. After drying, the prints are trimmed to within ¼ inch of the corner points for overlap mounting. The back of each print is abraded lightly along its edges with fine sand paper. The resulting thin feather edge makes a more attractive mosaic by reducing the "jig-saw puzzle" appearance of the matched prints.

MOSAIC PREPARATION

The transparent control sheet is laid out on a transparent glass-topped table illuminated from beneath. The individual triangular prints, which are translucent, are then glued to the sheet so that the print points coincide precisely with their corresponding points on the underlying control sheet and with the points in the overlap area of neighboring prints. Rubber cement applied to the sheet and to the print is allowed to dry until tacky before the print is emplaced. Minor adjustments in the print position are made before the cement dries completely. Any smears on the photographs may be taken off easily by gentle rubbing.

[1] Quartering the exposure time and increasing the recommended developing time assures the retention of the desired degree of contrast.

[2] The use of a paper developer rather than a film developer is a method resorted to by press photographers for increasing contrast without materially increasing grain size in the negative.

With the addition of a north arrow, scale, and names of geographic and cultural landmarks, the controlled mosaic base map is complete.

During the field season, the geologic data recorded each day can be transferred to the controlled-mosaic base map in a very few minutes the same evening. A conventional geologic map suitable for reproduction is made by tracing pertinent data from the photomosaic base map to a transparent or translucent overlay.

If publication of the controlled photomosaic base map is anticipated, it is essential to obtain permission from the agency supplying the aerial photographs.

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CLASSROOM STREAM TABLE

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ABSTRACT. A stream table can be used to show in miniature a wide variety of natural processes. The making of a simple but effective stream table, from readily available materials, is described.

INTRODUCTION

Nearly all the elements of the hydrologic cycle can be demonstrated by the use of a simply constructed stream table. It can show stream erosion in all its phases; creep, slump, and landslide; water table, wells, and springs; lakes, swamps, and marshes; canyons, rapids, and falls; beaches, bars, and deltas; currents, tides, and changing shorelines; effects of gradient change; and submergent and emergent coast lines. Blocks of ice covered with sand and gravel will portray a kame-and-kettle surface on melting. The stream table may be set up for an hour's use, or for a demonstration requiring many days. It is a perfect miniaturization, whose use is limited only by the experience and imagination of the demonstrator.

The following notes and diagrams are presented to those interested in constructing a serviceable two-section stream table that is neither elaborate nor expensive. The water source may be a faucet, or a tank with siphon and screw clamp. A metal Y or T, with rubber tubing, will provide two stream origins. An adjustable fine spray may be used to simulate rainfall on a local area.

MATERIALS REQUIRED

Marine plywood, ⅝-inch—43 sq. ft.
Coated nails, No. 6—1½ lbs.
Tar-fiber paste—½ gal.
Copper tubing, ¾-inch—1 ft; two ¾-inch stoppers
Strap hinges, 4-inch—four; twenty-four ⅝-inch screws
Piece of plate glass, 4 by 14 inches
Piece of waterproof fabric, 9 by 48 inches
Wire staples, ½-inch—2 oz.
Rubber tubing, screw clamps, metal Y or T connectors, as required
Aluminum foil, heavy—about 24 sq. ft.
Muslin—about 24 sq. ft.
Wood screws, 1¼-inch—24
Wooden cleats, 6-inch—4 (for corners)

CONSTRUCTION

Assemble the table as shown on Fig. 1, using tar-fiber paste on the joining surfaces and securing with coated nails at 2-inch intervals. Join the two sections

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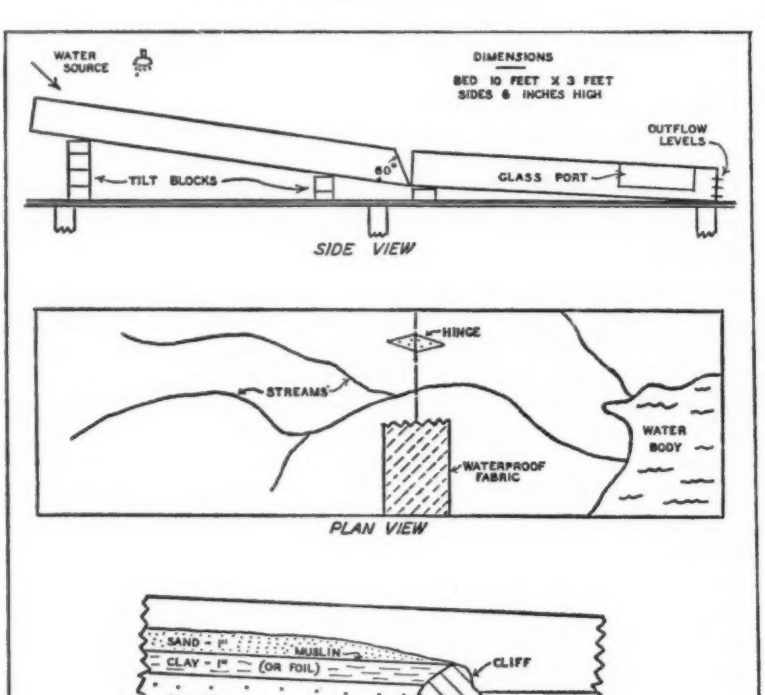

FIG. 1. Simple stream table for classroom use.

with four strap hinges. Coat the interior with the paste, and while the paste is still moist, cover the joint line between the sections with waterproof material secured by plenty of half-inch staples. For the side window use plate glass mortised into the plywood and waterproofed along the edges with the tar paste. Three short lengths of copper tubing provide outlets at different levels.

Dirt, clay, sand and gravel, and separating membranes of aluminum foil and muslin, will complete the set-up.

Notes. Placing a layer of muslin beneath the sand will allow recovery of the sand for re-use. To start table operation, saturate the whole bed by pouring water into the lower end. For wave action, use a paddle, paddle-wheel, or motor-driven screw propellor. For a short-time demonstration, such as development of a stream meander, pre-form the sand bed. If streams are not flowing, a mudded rock within the shore face will show a surface current toward the outflow, because of seep. A stream entering the water body adjacent to the glass port will show delta formation.

REVIEWS

The Geological Evolution of North America. A Regional Approach to Historical Geology. T. H. Clark and C. W. Stearn. vi + 434 pp., illus. Ronald Press Co., New York, 1960. $7.50.

This is an extremely well done book, combining clarity and readability with thoroughness and an up-to-date approach. Designed to be used as a historical geology text by students who have taken physical geology, it by no means follows the conventional cut-and-dried pattern of presentation. The authors make it known that the book represents a new approach to teaching the fascinating and complex subject of historical geology. It does!

The historical development of the North American continent is presented in terms of its three major structural units: the stable interior, the bordering geosynclines, and the Canadian Shield. Emphasis is placed on analysis and interpretation, so the reader has a clear idea of the similarities and differences in the behavior pattern of these structural elements.

The book is divided into five parts and two appendices. Part I deals with the usual introductory material on the scope of historical geology and the earth in the universe. The authors are to be commended for a superb presentation of the methods and problems of correlation. To stress evolutionary similarities between geosynclines, a chapter on the geosynclinal theory is included, so that the student will gain (as the authors put it) an appreciation of the tectonic "woods" before Parts II and III bring him to an examination of its "trees." Pre-Pennsylvanian sedimentation in the stable interior is also discussed in the introductory section. Because sedimentation in the interior was predominantly influenced by source areas in or near the flanking geosynclines after Mississippian time, the later geologic history of this structural unit is developed in Parts II and III, where emphasis is directed to a study of the Appalachian and Cordilleran geosynclines.

Part IV treats the evolution of the Franklin geosyncline in the Arctic Islands, to complete the description of the flanking basins so that analysis of the intricate geology of the Canadian Shield, to which the major portion of this section is devoted, can be more easily appreciated. It concludes with an excellent chapter on the Pleistocene history of North America, but it seems odd that Clark and Stearn fail to mention the Ewing-Donn theory as one possible explanation for Pleistocene glaciation.

Life of the major divisions of geologic time constitutes Part V. This section is supplemented by the two appendices, which are designed to fill the student's insufficiencies in biological background. The first appendix is a classification of plants and animals. It considers the interrelationships of the organisms described in Part V. The second is a summary of the plant and animal kingdoms, which stresses those organisms that have left a satisfactory fossil record.

Throughout the book are well-prepared diagrams and carefully selected photographs. Of particular importance are the facies maps, which clearly show the importance of sedimentary facies patterns in the interpretation of geologic history. Once a course is completed in which this book is used, the student should take with him a thorough understanding of the principals of continental evolution and the ability to interpret facies patterns.

There are remarkably few errors in this excellent first edition. Somerville (erosion surface) is consistently spelled with two "m's". The reference to Figure 16-14 gives the wrong page. Actually the book is devoted to the evolution of the United States and Canada, and not to the whole of North America as the title implies; but this implication can be overlooked in the light of the geographic distribution of the major structural units with which the book is concerned.

Hurrah for the use of unpretentious terminology relating to geosynclines, and for the modern approach to stromatolite formation!

Because it does not follow the typical chronologic approach of standard historical texts, and because it emphasizes the influence of structural events in source areas and in basins on the accumulating sediments, this book is uniquely qualified as a basic text or

reference volume in many areas of geology. The clarity and simplicity of presentation of so complex a subject is such that no one should fail to envision the sedimentary and structural history of North America. The book seems certain to be considered one of the best in the field.

I like it!

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Historical Geology, 2nd edition. Carl O. Dunbar. ix + 500 pp. John Wiley & Sons, Inc., New York, 1960. $7.95.

If you or your students liked the older Dunbar (1949), you will like this one even better: it is bigger, has larger illustrations, more text, and every chapter is improved. But you will not feel lost, for the whole arrangement, even to chapter headings, is almost identical; basically it is the same book.

If you are not familiar with the first edition, what you will find in the new is a straightforward, factual account of what happened, never introducing problems or uncertainties. You will not be bothered by searching questions like: why does one use paleogeographic maps when they hide so many "unknowns"; how does a fossil get to be a guide fossil, and what is the ultimate "resolving power" of fossils; what are the uncertainties of radiocarbon dating; or, what do genetics and paleontology *not* explain about the history of life? Recent topics that have stirred the geologic fraternity are treated lightly or not at all: there is no adequate discussion of turbidity currents, paleomagnetism and continental drift, deep sea cores, or even of ecology.

The one major change seems to me a poor one. In the old book there was a kind of continuity in the first four chapters, especially from "Fossils, a Living Record of the Dead" to "The Constant Change of Living Things." Now a rewritten chapter, "Cosmic History of the Earth," is put between these two. If I had it to do, I would start out with "Cosmic History" (or leave it out altogether), then do Precambrian history, and only after that, or along with it, introduce "Records in Stone" and "The Scale of Time." The logical place to put fossils and evolution is after the student has seen the need for them, in the Cambrian.

The only serious error spotted was the interchange of charts on pages 326 and 366. The map of Early (= Lower?) Cretaceous on page 320 lacks sediments of this age that occur in Maryland and Virginia. The Eocene map on page 354 has a ghostly Mississippi Embayment, and there seem to be no deposits of this age in the Rocky Mountain area.

This is a polished and improved first edition. My venture is that we shall not see another text of this type. I believe that we shall be forced either to treat certain areas and times in more detail, or we shall have to resort to principles, as recent stratigraphy texts have done.

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Dana's Manual of Mineralogy, 17th edition. C. S. Hurlbut, Jr. xii + 609 pp., 634 figs. John Wiley & Sons, Inc., New York, 1959. Professional edition $11.50, textbook edition $9.50.

The new edition of the *Manual,* although retaining its familiar appearance and arrangement, contains much that is new in concept and information. It has been brought thoroughly up-to-date in a most economical fashion, and yet one which has subtly changed (for the better) the underlying method of the book. In addition to the overall modernization, the inclusion of numerous references for further reading is a decided and long-needed improvement. The major changes have been made in the chapters headed: "Crystallography", "Chemical Mineralogy", and "Descriptive Mineralogy".

"Crystallography" has been extended by a description of the stereographic projection and its application (and a 10-cm. radius E-half Wulff net imprinted on the back end-paper); by stereograms illustrating the symmetry of the crystal classes; by methods and examples of calculating axial ratios; and by a 22-page summary of X-ray crystallography. The emphasis remains upon the observational features of morphological crystallography.

"Chemical Mineralogy" now begins with a lucid and reasonably inclusive 34-page summary of crystal chemistry. The treatment

should be perfectly comprehensible and useful to anyone who has had at least one semester of "freshman chemistry." The most important omissions are explicit considerations of non-stoichiometric mineral compounds, crystal imperfections, and the types and importance of order-disorder. Moreover, in an immediately following section concerned with the derivation of mineral formulae from analyses, no consideration is given to how formulae are obtained in the general situation in which a mineral exhibits some degree of solid solution. The concluding section, "Instruments and Methods of Testing", has been pruned from 35 to 11 pages.

"Descriptive Mineralogy", the backbone of the book, describes the same minerals (with only one or two minor additions) as its predecessor. The arrangement throughout is based on the "Dana's System"—Strunz classification; the silicates, therefore, begin with the structurally simpler polymers rather than with the framework types as in the previous edition. Much description of structural features has been added in the form of text, diagrams, and clear photographs. A few phase diagrams have also been included. A very high proportion of the recent significant findings on the different mineral species seems to have been considered in the revision of this chapter. The addition of more diagrams showing the ranges in solid-solution composition and the variation of properties with composition would aid considerably in providing a better insight to the nature of many mineral species.

All in all the new edition is a conscientious and effective revision and undoubtedly will continue to be the mainstay for a great many courses in introductory mineralogy.

D. M. HENDERSON
University of Illinois

General Crystallography: A Brief Compendium. W. F. deJong. x + 281 pp., 231 figs., 41 tables. W. H. Freeman and Co., San Francisco, 1959. $6.00.

General Crystallography is a translation-revision of the author's *Compendium der Kristalkunde,* published in Dutch in 1951.

The book contains a highly condensed synopsis of practically the full range of crystallography—classical morphological crystallography, X-ray crystallography, crystal chemistry, and crystal physics. Some idea of the level and range of treatment may be indicated by the following rather arbitrarily noted topics or features: description of projections, use of determinants in crystal calculations, outline of Fourier analysis, summary of structure types, descriptions of organic fiber structures, application of tensors in crystal physics, consideration of homogeneous deformation, summary of crystal optics, consideration of crystal defects, and description of semi-conductors. So wide a range of treatment in a book of this size leaves little room for explanation and discussion. Nontheless, many persons already having a fair knowledge of crystallography may find it a handy source for refreshing their memory and for obtaining new points of view. The references cited (classical as well as up-to-date ones) for almost all topics will be of particular value to such readers.

D. M. HENDERSON
University of Illinois

Our Mineral Resources. Charles M. Riley. x + 338 pp., 102 figs. John Wiley & Sons, Inc., New York, 1959. $6.95.

Charles M. Riley prefaces *Our Mineral Resources* with an explanation that the book is designed for an elementary course in economic geology, either as ". . . an introduction to a curriculum for the training of a professional geologist . . ." or ". . . as a cultural course in earth science attended by students seeking degrees in other fields." The former objective, it seems to me, is not likely to appeal to most geology schools, as the present emphasis is toward shortening the preliminaries and pushing students into and through the basic courses as rapidly as possible. The applications, such as petroleum geology and economic geology, are subjects in which a student can train himself if he has the inclination. Self-training in fundamentals, such as mineralogy, structural geology, and stratigraphy, is much more difficult.

The author's second objective is more likely to make the book a success. Broad and therefore necessarily superficial treatment is desirable in a text for the non-professional, and the author has made his book interesting and understandable to the person who has

mastered the essentials of elementary geology. I am using the text for the geologic part of a cultural course designed to show the impact of mineral resources on world history, colonization, economics, and international affairs. The weak students find it difficult, the strong students find it a trifle elementary, and my general impression is that Riley has pitched the presentation at an appropriate level for this purpose.

To comment briefly on some of the ways in which I think the book might be improved, I should like to touch first on the balance between the resources covered. I would not contend that the economic importance of particular commodities should be the sole guide to their coverage, but the student may acquire a distorted impression of the mineral economy from the attention that major resource groups receive in the book. The fuels, which constitute about 70 percent of our mineral production *(Minerals Yearbook 1958)*, are covered in 11 percent of that part of the text devoted to commodities. The metals contribute less than 10 percent of the production value but occupy 60 percent of the page space within the commodity sections. The nonmetals, at 20 percent of the gross production value, occupy 28 percent of the space and are, of course, grossly out of balance with either metals or fuels.

Coverage of individual commodities also seems capricious in places. Building stone is discussed in three and one-half pages, but crushed stone, with enormously greater production tonnage and value, is dismissed in one-third of a page. Clay mineralogists will wince to learn that clays are covered in less than a page and are not listed in the index.

Presumably every book has its strong and weak points, and I should say that the industrial minerals suffer in this one. Numerous terms are incorrectly used (dimension stone, ashlar), and the selected references are largely obsolete for some nonmetallic materials. Gems receive extensive attention, probably justifiable on the basis of interest to the layman, and chemical raw materials are dealt with in relative detail, although calcite and silica for chemical uses are not mentioned in this section. Illustrations, both photographs and line drawings, are well chosen and well done.

Finally, I consider that the author deserved more assistance than he received from editor and publisher. Many geologists are less than enthusiastic about direct adherence to *Suggestions to Authors*, but few will doubt that *Our Mineral Resources* would have been substantially improved by a trip through the editing route of a geological survey. The most annoying of the deviations is the repeated use of "this" or "these" following headings, with the result that countless sentences cannot stand alone because their meaning is dependent upon the heading. Indirect approaches ("there is", "there are") abound, multiplying words and weakening sentence structure. The word "figure" is abbreviated at the head of the figure captions, which is the equivalent of using initials on a birth certificate. Shame on John Wiley!

JOHN B. PATTON
Indiana University

Subsurface Mapping. Margaret S. Bishop. 198 pp. John Wiley & Sons, Inc., New York, 1960. $5.75.

Mrs. Bishop explains that the purpose of the book is to suggest an approach to the problems of subsurface mapping, though it cannot supply the answers. It is emphasized throughout that a broad geological background is essential for the adequate treatment of subsurface data.

The eleven chapters include (1) Introduction to Subsurface Mapping, (2) The Preparation of Contour Maps, (3) The Preparation of Cross Sections, (4) Topographic Maps, (5) Terminology of Stratigraphic Maps, (6) Structure Maps, (7) Isopach Maps, (8) Facies Maps, (9) Paleogeographic Maps, (10) Geophysical and Geochemical Maps, and (11) Map Evaluation. There is a bibliography of 13 pages, and an excellent index.

A vast amount of material has been condensed to 198 pages of text. The major weaknesses of the book stem from this extreme condensation. However, the extensive bibliography should aid anyone who desires a more complete treatment of almost any problem in subsurface studies. Perhaps the major contribution of the book lies in its tendency to focus attention on a phase of geology too often excluded from acadamic thinking.

The author emphasizes the interrelationships of surface and subsurface geology, and since so many of the presently available data are in the form of logs and seismic records, it behooves us all to consider surface and subsurface geology at least as equal partners.

Chapter 2—The Preparation of Contour Maps—may be considered a primer for anyone using isopleth maps. The chapter covers contouring from the standpoint of five basic rules, with illustrations of the application of each. It concludes with a discussion of the mechanics of contouring.

Chapter 6—Structure Maps—discusses the map most familiar to the majority of geologists. It is one of the strongest chapters in the book, and because of readers' wide familiarity with this type of map, will be one of the most seriously criticized.

Chapter 7—Isopach Maps—has an excellent section on interpretation, and an extensive treatment of the use of the isopach map in petroleum reservoir studies. This latter portion has equal application in groundwater problems, as well as in some commercial rock-and-mineral ventures.

Chapter 10—Geophysical and Geochemical Maps—is, in the reviewer's opinion, the weakest in the book, because too much geophysical work is considered on too few pages of text.

In summary, the book appears to be an improvement on anything published on this subject to date—it encourages (and aids in) the use of subsurface data. Its major weaknesses stem from its small size and broad coverage. It is hoped that future editions will assume less knowledge on the part of the reader and explain more fully some of the fascinating phases of subsurface work which are now only touched upon. The author is to be commended for this first effective treatment of a topic too seldom mentioned in many schools.

O. T. HAYWARD
Baylor University

The Sea Off Southern California—A Modern Habitat of Petroleum. K. O. Emery. 366 pp., 248 figs., 1 plate. John Wiley & Sons, Inc., New York, 1960. $12.50.

The title of this book is perhaps a little misleading. Dr. Emery has undertaken the impressive task of summarizing and integrating into a coherent whole the existing information concerning one of the most thoroughly studied areas of the modern oceans. Wherever possible he attempts to relate this information to the general problems of the origin and accumulation of petroleum, but the book does not attempt to develop or defend the thesis that the California coastal basins represent a region of modern petroleum accumulation typical of those in the geologic column. Rather, the author presents in detail, and with abundant references to original sources, our present knowledge of each aspect of the physical and biological environments of these basins, shows their interrelations, and leaves the reader to draw his own conclusions.

The author discusses the physiography, lithology, and geological structure of the region, both above and below sea-level, and summarizes what is known of the movement of water masses (though surprisingly he says little of the chemistry of sea water). He identifies the major floral and faunal provinces and describes their characteristic assemblages, and briefly treats a few economic aspects of marine investigations in the area. The most important section of the book is devoted to modern marine sedimentation. Here are described the sediments found in each portion of the area, together with discussions of their mineralogy, chemistry, texture, and probable origin.

As a compendium, the book is an outstanding success. It is unique in the field of marine geology, and provides a comprehensive reference to a large body of published and unpublished data. (The bibliography includes almost 825 entries.) It is not a textbook in any sense, however, and its appeal to the lay reader may be limited, as the author has chosen to juxtapose rather elementary generalizations and highly sophisticated scientific arguments. He turns, for example, from the experiences of bathers on a beach (in speaking of rip currents and "undertow") to a discussion of man-induced currents requiring of the reader a thorough familiarity with the concepts of dynamic topography and Coriolis' acceleration. The result, however, is to provide the selective reader with a wealth of well-illustrated and interesting information concerning the sea

in general and the California coast in particular. The book should be a valuable reference work for teachers in general geology, as well as for students of the marine sciences.

ROBERT F. SCHMALZ
The Pennsylvania State University

Hydrology, 2nd edition. C. O. Wisler and E. F. Brater. xiv + 408 pp. John Wiley & Sons, Inc., New York, 1959. $9.25.

This text is written by engineers for engineers, but it is also an excellent introduction to hydrology for earth scientists. The first edition has been used at Ohio State University, on occasion, as a text for a course in the geology of water resources. Although the engineering approach is not used in most such courses taught by geologists, a teacher can complement geological lectures with this hydrological text.

The second edition is much improved over the first. Most important, the chapters are divided into more numerous titled sections than formerly. Thus the organization of topics is more readily apparent to students, and coherent reading assignments are more easily made. It is also easier to select certain topics or sections for use or for omission. A chapter on the hydrology of semiarid regions has been added. The discussion of snow has been reorganized and expanded. Both of these changes make the book much more useful. In addition, the authors have introduced a new method for applying the unit hydrograph to the prediction of floods.

If *Hydrology* is not suited to one's requirements for a text, it should certainly be made available to students of earth science for a reference.

MALCOLM P. WEISS
Ohio State University

Microscopic Sedimentary Petrography. Albert V. Carozzi. viii + 485pp., illus. John Wiley & Sons, Inc., New York, 1960. $11.50.

This advanced text is an up-to-date treatment of the miscroscopic characteristics of the sedimentary rocks. The author has brought together considerable information from the American and European literature on the more commonly occurring rock types. In addition to covering the broader classifications, he has also discussed petrogenesis, alteration, recrystallization, and replacement phenomena, and has furnished much information on sedimentary textures.

Part 1 deals with the clastics—the arenites, rudites, pyroclastics, and argillaceous rocks, but not the clastic limestones. Part 2, entitled biochemical rocks, covers the carbonates and the siliceous, iron-bearing, and phosphoric rocks. Part 3, chemical rocks, deals only with evaporites. The subject matter has been placed under 9 chapter headings as listed above, and is illustrated by 88 well-captioned figures, mostly photomicrographs. The text is well written and quite usable, owing to the elaborate breakdown of subject matter under the various headings and subheadings.

The treatment of the limestones, pyroclastics, and argillaceous rocks is particularly good. The author has devoted only two pages to the lithic sandstones (subgraywackes), the most common sandstone type. A greater number of illustrations would be desirable in most sections of the book. The graywackes and subgraywackes are not illustrated. Part 2 is not properly titled, since many rocks discussed under the heading of biochemical may be purely chemical in origin. Tufa and travertine are not mentioned, even though they are largely chemical rocks. This reviewer is disturbed by the author's use of *often, frequently, occasionally,* etc., with regard to commonness of occurrence of minerals. A beginning student of sedimentary petrology should study the preface and introduction of this text at the outset.

WAYNE MARTIN
Miami University

Physical Science. Donald S. Allen and Richard J. Ordway. xi + 825 pp. D. Van Nostrand Co., Princeton, N. J., 1960. $8.25.

This text, ". . . written for the non-science major who has little or no previous training in science and no mathematical training beyond elementary algebra," is liberally provided with excellent diagrams and illustrative examples, and many good photographs. The range of topics covered seems about equal to that of other physical-science survey texts, although the authors state that the attempt

was made ". . . to limit the discussion to a few selected topics and treat each with the same thoroughness." Obvious care has gone into presenting the material at a level not above the student's background; perhaps, in some cases, to the extent that the attention of adequately prepared students may wander. For example, included are a few very elementary topics, such as the pictorial presentation of algebraic equations ($x + 6 = 10$, etc.) as scales in balance, which though well done, seem to place too much emphasis on remedial work.

The thoroughness is not quite uniformly extended throughout the selected topics; the chemistry and geology sections are replete, as would be expected with the backgrounds of the two authors, but the student will never struggle with the problem of the wagon pulling the horse, as the short paragraph on Newton's third law doesn't go that far. Occasional opportunities to sharpen the student's precision of thought are sacrificed to keep concepts as familiar as possible; for example, "An earthquake is a shaking, trembling, vibratory motion of the Earth's crust" (p. 710) seems a less instructive definition than the more common one found in Webster (1947 Collegiate). In general, however, depth is ample for an introductory survey course, and those students who would otherwise have difficulty should find the book especially readable.

The geology section deserves special mention, as in general it is as good as or better than those in several of the current crop of combined-survey texts. Occasionally a few words might have been added (or deleted) to keep from overdirecting the students' thought or to indicate more of the current classic struggles (e.g., pp. 396-397 on the Carolina Bays and pp. 687-688 on the geothermal gradient), but it is to be noted that the evolution of the horse is treated in a modern manner, and for the most part there is not much dogmatism. The selection or reproduction of several of the photographs mars the geology section somewhat. Fig. 25-9, p. 538, "Large anticline", for example, has too much erosive topography and a river bend that leads the eye away from the pertinent subject. The following photographs are especially poor (insufficient contrast, out-of-focus, or merely poor reproduction): p. 572, Fig. 26-7; p. 595, Fig. 27-4; p. 703, Fig. 31-8; p. 723, Fig. 32-2. Some others are of dubious instructive quality. On the whole the photographs in the geology section do not add nearly as much to the book as do the excellent diagrams.

The chemistry in the first part of the text could have been integrated with the mineralogy (and perhaps crystal chemistry mentioned), but the over-all organization is convenient. The first 14 chapters are devoted to physics and chemistry, then seven to astronomy, two to meteorology, nine to physical geology, and finally one to the fossil record. The physics and chemistry chapters have 13 accompanying laboratory exercises, which, though short, should be very useful.

N. C. JANKE
Sacramento State College

Elements of Cartography, 2nd Edition. Arthur H. Robinson. 343 pp. John Wiley & Sons, Inc., New York, 1960. $8.75.

This new edition of Robinson is an excellent text and reference book for any teacher, researcher, or student, especially within the earth sciences, who must make his own maps and diagrams. It is broad in scope, attempting to cover the primary process of cartography, defined by Robinson as "the conceptual planning and designing of the map as a medium for communication or research."

Professor Robinson is eminently qualified in the field of cartography. His broad experience includes university teaching, government work in wartime, and the publication of many articles. His style of writing is smooth yet succinct, his illustrations pertinent and lucid.

According to the author, the most important changes in the second edition are expanded treament of symbolization and representation of mapped data, the inclusion of some elementary statistical concepts, and more material on map projections.

The material is well organized, perhaps more logically than in the first edition. Robinson starts out with a brief but adequate introduction to cartography, then turns to a discussion of the shape of the earth, measurements upon it, and geographic coordinates. This is followed by a chapter on cartographic drawing and measuring techniques.

There are three chapters on map projections, a fundamental, complex, and often puzzl-

ing realm of cartography. This section has been considerably expanded over that of the first edition, and the presentation is clearer. The new material on distortion and deformation is especially good in helping students understand the inevitable distortion of every projection.

The other section which has been considerably broadened is that on symbolizing and processing map data. It analyzes the use of statistical material with a view to vivid yet accurate graphical representation. The excellent discussion of elementary statistics could be very valuable to the uninitiated student or researcher who must translate raw data into meaningful visual terms.

Robinson then clearly sets forth the unique problems arising from two-dimensional representation on maps of the three-dimensional surface of the earth, i.e. topography. This chapter includes detailed discussion of contours, hachures, shading, physiographic diagrams, and some lesser-known methods of depicting relief such as slope-category and relative-relief. It is unfortunate that most of the fine physiographic diagrams and maps by Lobeck, Raisz, Harrison, Tanaka, and the U. S. Geological Survey have been reduced to such a small scale that much of their effect has been lost.

Following chapters on map design and lettering is an expanded and up-to-date chapter on map reproduction. This describes not only the final printing processes, but all the intermediate stages of preparation.

An appendix includes various algebraic and trigonometric data; geographical and projection tables; and a bibliography of selected references, topically arranged.

Although the scope of the second edition is broader than that of the first, there are still two striking omissions. The first is the lack of reference to surveying. Robinson says nothing about plane-tabling or triangulation, or newer mapping techniques involving sonic or radio waves. It is important for a mapmaker to have some familiarity with the method (including speed, cost, and accuracy) of accumulation of basic data. The other omission concerns aerial photography and photogrammetry. It would seem most pertinent to say something about the interpretation of aerial photographs from a cartographer's point of view, and to discuss methods of transforming topographic data from stereoscopic pairs by means of stereo-plotters into actual maps.

It might be said that an excessive amount of mathematics has been included, more than might be appropriate for an elementary text. However, the use of this book for advanced textual and reference purposes probably justifies the amount of mathematics.

In summary, *Elements of Cartography* is a well-written book, of great value to anyone concerned with the conception, construction, preparation, and reproduction of maps and diagrams. From it may be gained an understanding of the complexity, effort, and expense involved in mapwork, as well as guidance when teaching others, or when preparing maps or charts for demonstration purposes, slides, or publication.

JANE LANCASTER
Barnard College,
Columbia University

REPRINTS OF JOURNAL INDEX ARE AVAILABLE

Separate copies of the "Index, Volume 1 (1951) Through Volume 7 (1959)," which appeared in the Spring 1960 issue, are now available. They may be obtained at 50 cents each from the national treasurer, Dr. Sheldon Judson, Department of Geology, Princeton University, Princeton, New Jersey.

TRANSACTIONS OF THE NATIONAL ASSOCIATION OF GEOLOGY TEACHERS

EASTERN SECTION

On Saturday, December 12, 1959, thirty-three geologists from Adelphi, Barnard, Bryn Mawr, C. C. N. Y., Columbia, Franklin and Marshall, Hofstra, Hunter, Lafayette, N. Y. U., Princeton, Rensselaer, Rutgers, Trenton State, University of Pennsylvania, Upsala, and Villanova met at Columbia University for the *fifth annual informal meeting* of the Eastern Section, National Association of Geology Teachers.

The group met in the Geology Department library. This has a total of about 50,000 volumes, bound and unbound. There is a map librarian for the 75,000 maps in the collection, and the maps are partly catalogued. Unfortunately, there is no room for the expansion of the map collection.

The group was taken on a tour of the department, visiting about thirty lecture rooms and laboratories. The large amount of modern equipment for mineralogical research was particularly impressive.

At Columbia the emphasis is on the graduate program, with 22 staff members and 84 graduate students. Fifteen Ph.D. degrees are given each year. There are only 16 undergraduate students majoring in geology at present.

Professor Paul F. Kerr, research coordinator, gave an illustrated review on "Geologic Research at Columbia," pointing out that research is carried out not only on campus and in countrywide field work, but also at the Lamont Geological Observatory, at the American Museum of Natural History, at Bimini in the Bahamas, in Bermuda, on Arctic ice islands, and on the ship, *Vema*, with its oceanographic program.

After luncheon at the Men's Faculty Club, the party separated into two groups. One group was taken to the Lamont Geological Observatory, and the other visited Barnard College where Professor Henry Sharp conducted the group around the laboratories. At Barnard there is an undergraduate program of basic courses, for women students only. Occasional advanced courses in geomorphology are open to Columbia College students, while Barnard students have the advanced courses and library facilities of Columbia University available to them. The main objective at Barnard is to maintain geology as a liberal-arts subject.

Professor E. H. Colbert led a visit to the American Museum of Natural History. He discussed the general relationship between research in vertebrate paleontology and museum display. Preparation and storage rooms for vertebrate fossils were visited, including a fossil display in production. New ways of exhibiting restored vertebrate skeletons were discussed.

The Eastern Section of the National Association of Geology Teachers held its *tenth annual meeting* on April 1st and 2nd, 1960, at Dickinson College, Carlisle, Pennsylvania, with 32 geologists from 17 colleges attending.

On the afternoon of April 1st, the members were invited to the Pennsylvania Bureau of Topographic and Geologic Survey, Harrisburg, Pennsylvania. They were conducted on a tour of the new laboratories and library.

After the annual dinner, at the James Wilson Hotel in Carlisle, Lincoln Dryden, Section president, thanked the Dickinson geology department for its hospitality. The business meeting was held at Althouse Science Hall at 8:30 P. M. Maurice B. Rosalsky read the treasurer's report, which revealed that the section is on an even keel financially. He also read the membership report, which showed 11 members dropped out and 30 new members added largely as the result of his membership campaign. The section now has the highest membership in its history—162 members.

The slate of officers presented by the nominating committee (see inside back cover) were elected by mail ballot. Lincoln Dryden was elected as section representative on the national nominating committee for 1961.

Following a directive at the meeting, Joseph Rosenholtz wrote to and received a promise from the New York State Museum and Geological Survey to be our host at our one-day Fall Meeting on December 3, 1960. The section agreed to have our annual meeting next spring at Colgate University.

Winthrop Difford spoke to the group about geology as taught at Carlisle, and then on "Geology of the Carlisle Area." Jacob Freedman reported on the Duluth Conference for the development of teaching resources at the secondary-school level. One conclusion reached at the conference was that with general science taught in the 7th and 8th grades, earth science should be taught in the 9th grade. With the "big push" for 9th-grade earth science in New York and Pennsylvania there is certainly a need for a teacher's resource book in that subject.

Kurt Lowe showed the group models made at C. C. N. Y. to illustrate strike and dip, plunging folds, and the Pratt and Airy concepts of isostasy.

On Saturday morning, April 2nd, there was a symposium on "Teaching Structural Geology." The speakers were Ernst Cloos, Johns Hopkins; Fred Donath, Columbia; and Don Wise, Franklin and Marshall. All stressed the importance of field work, and of thought and judgment in structural geology.

In the afternoon, the group took a field trip to South Mountain (end of the Carlisle Prong of the Blue Ridge) and into the Great Valley to study Paleozoic rocks.

MAURICE B. ROSALSKY, *Secretary*

EAST-CENTRAL SECTION

The annual meeting of the East-Central Section, combined with that of the Southeastern Section, was held in the afternoon of March 25, 1960, at the Phoenix Hotel in Lexington, Kentucky. Section presidents R. H. Mahard and W. R. Higgs presided. The program was a symposium devoted to basic curriculum needs for undergraduate geology students, and careers open to geologists. Panel members who led the discussion were Lois R. Campbell, Charles Bieber, and Karl Limper. Views on curricula were in general agreement with others recently expressed, but there was considerable discussion of unrecognized career opportunities for geology majors.

The business meeting of the East-Central Section that followed was attended by only 11 members. Since a quorum was not present, the group constituted itself an executive committee and nominating committee. The report of the treasurer, showing a balance of $148.00, was accepted. Previous mail balloting resulted in the election of new officers (see inside back cover), and it was reported that Section members had voted to contribute $50.00 to the *Journal of Geological Education* and $50.00 to the American Geological Institute. The ballot also showed a strong desire of the members to amend the Section by-laws for the selection of officers.

CHARLES E. GRAHAM
Secretary Pro-Tem.

CENTRAL SECTION

The 20th annual meeting of the Central Section was held at the University of Kansas, Lawrence, on March 27, 1960. President Duncan Stewart presided. The minutes of last year's meeting were approved as published in this *Journal.*

The treasurer's report showed a balance on hand of $102.38. In addition, the Section owns two government Series J savings bonds, the market value of which is $75.90 each. The treasurer's report was approved.

Section editor Wakefield Dort reported that he had received no manuscripts from Section members to forward to the national editor.

The budget committee recommended a budget appropriation of 55 percent of anticipated income. The unspent portion of last year's appropriation will be added to the reserve fund and used to purchase a government savings bond. The report was approved.

The auditing committee approved the treasurer's records and moved their acceptance. This was passed.

The nominating committee presented a slate of new officers. It was moved, seconded, and passed that the nominees chosen by the committee be elected (see inside back cover).

Christian Amstutz presented a brief report of the annual meeting of the National Association of Geology Teachers held in December 1959 at Ohio State University.

Henry Woodard remarked that the scheduling of the Central Section meeting in very early spring was a great help to many teachers who had a heavy schedule of field trips during the spring term. Several others were in agreement.

President Stewart announced that the next meeting of the National Association would be held in connection with the G. S. A. meeting in Denver in November 1960. Charles

Campbell has issued an invitation for papers in behalf of the National Association.

The program consisted of three symposia. The first, on *Field Work in Geological Education*, included papers by P. D. Proctor, K. M. Hussey, H. H. Woodard, F. L. Koucky, and J. M. Jewett. Papers of the second symposium, *The New Mineralogy*, were by A. F. Hagner, Elliot Gillerman, D. J. Gore, H. D. Carlson, and D. M. Henderson. *Geology in the High Schools* was discussed by G. M. Wilson, Grace Muilenburg, Ada Swineford, Allison Hornbaker, and J. M. Jewett.

DOROTHY J. GORE, *Secretary*

FAR WESTERN SECTION

The annual meeting was held April 9 and 10, 1960, at Los Angeles State College. The theme this year was "Some Recent Advances in Geologic Knowledge Significant for Undergraduate Teaching."

The meeting was called to order at 9:15 by President A. O. Woodford, who immediately asked the Secretary-Treasurer for an account of the organization's business activities. Secretary-Treasurer G. J. Bellemin announced that the paid-up members of the organization now numbered 66, including 10 new members. He reported that the section's bank balance as of April 1st was $102.95, but a few bills were still outstanding and would be paid before closing this fiscal year. He also announced the results of the 35 ballots returned for next year's officers (see inside back cover).

Dr. Woodford then called for nominations for membership on the national nominating committee. Dr. Richard Merriam was nominated, seconded, and unanimously elected. Dr. Woodford announced that San Francisco State College had invited the Section to its campus for next year's meeting. This invitation was put to a vote and unanimously accepted. The meeting was then turned over to the Vice-President, Dr. Merriam, who presided at the morning program.

The first speaker was Dr. Thane H. McCulloh, who presented "Isostasy and the Los Angeles Basin." Dr. McCulloh's work included determining the specific gravity of specimens of each of the available subsurface units, and using the results to calculate values for g, which were then compared with observed values. This procedure surprisingly erases the major anomalies from the Los Angeles Basin, with the exception of highs in the Palos Verdes area and around El Toro. He concluded that the Los Angeles Basin is in isostatic equilibrium.

The second speaker was Dr. K. O. Emery on "Formation of Petroleum in Southern California Basins." Many aspects of the basins were presented, including the forms of deposition, character of the deposits, water temperatures, etc., all of which pertained to the development of organic material in the basins. The major conclusion was that considering the bio-chemical chain of life, there is far more than enough petroleum-producing material forming in the basins being filled today to account for the presence of petroleum in the quantities exploited in nearby Tertiary basins.

The meeting adjourned for lunch in the college cafeteria, after which a short tour of the Los Angeles State College geology department was conducted by our hosts, Dr. J. Richmond, Dr. P. Ehlig, and Dr. R. Mead.

The afternoon session on geologic age was held with G. J. Bellemin in the chair. The first speaker was Dr. G. J. Wasserburg, who discussed "Ages Based on Radioactive Transformations: Methods, Reliabilities, Results." Dr. Wasserburg described the useful radioactive series: Pb/U, Pb/Th, Sr/Rb, A/K, and Carbon 14. He then described the values and possible errors for each method. The oldest date obtained on rocks in North America is 2.6-2.7 billion years, from Cook County, Montana. The most serious discrepancies in ages determined are between different minerals in the same or different rocks. Zircon, for example, holds the products of radioactivity better than the micas do.

The second speaker, Dr. O. L. Bandy, presented some "Cenozoic Correlations Based on Planktonic Foraminifera." The problems of taxonomy and correlative factors were discussed. It was suggested that the predominant coiling patterns (dextral or sinistral) of the foraminifera may in favorable cases be used to determine whether one is dealing with a cold-water or warm-water fauna and thereby identify changes of conditions in an area which may coincide with time zones.

The evening dinner was held at Rickey's in Alhambra with 28 present, including several members' wives.

Dr. V. L. Vanderhoof of the Santa Barbara Museum spoke on "Early Geologic Maps of California" and on the value of the history of geology in teaching the subject. The interesting talk, well illustrated with slides, described the first mapping of California, from the "Geological Plan of the Port of San Francisco," made by rowboat in two days in 1839 by Lt. E. Belcher, R.N., F.G.S., to several maps published in 1857 in conjunction with the railroad surveys of the west.

The Sunday field trip was conducted by Dr. R. H. Jahns of the California Institute of Technology. The main themes were the structural characteristics and major rock units of the western San Gabriel Mountains. Dr. Jahns pointed out that this range is basically very complex, and is difficult to map because of the physical effort required and the complexity of the geology. The major plutonic rock units are a Precambrian anorthosite complex dated by Pb/U at 1,250 million years old, and Mezozoic plutonics of granite and quartz diorite. The metamorphic units consist of the Mendenhall gneiss, 1,400 million years old, the San Gabriel gneiss, and the Pelona schist. The sediments in the Soledad Basin north of the range are Eocene-Pleistocene, in part marine and in part continental, the latter interbedded with volcanics. The major fault systems of Southern California appear in the range. Essentially these include a northwest-southeast strike-slip multiple fault system (San Andreas, San Gabriel, and Sierra Madre) with right lateral movements. Dip-slip and thrust faults complicate the structure.

The field trip was concluded at about 3:00 p. m. All the participants felt that it had been well worth while.

GEORGE J. BELLEMIN, *Secretary*

PACIFIC NORTHWEST SECTION

The Section held its annual meeting jointly with the Northwest Scientific Association at the Davenport Hotel in Spokane, Washington, on December 28 and 29, 1959. The business meeting was held on the afternoon of the 28th, following presentation of papers by Rolland Reid and Norman Anderson. Section president W. Frank Scott presided.

Reading of the minutes was dispensed with, and after a report on the status of the treasury, Charles Campbell, chairman of the nominating committee, announced the new officers elected by mail ballot (see inside back cover). E. F. Cook was elected representative to the national nominating committee.

Charles Campbell, national vice-president, called the group's attention to the November 1960 meeting of the National Association of Geology Teachers, to be held jointly with the G.S.A. in Denver, Colorado. He announced that tentative program plans include a symposium on "Use of Languages in Geology Teaching."

The Pacific Northwest Section will meet jointly with the Northwest Scientific Association, December 1960, at Moscow, Idaho.

ERNEST H. LUND, *Secretary*

EXCHANGE PROGRAM

At its meeting in December 1959, the Executive Committee of the N.A.G.T. approved the establishment of an exchange program within the Association. Such a program was operated successfully for several years within the Central Section but is now dormant.

Items that have been suggested as possible exchange material include fossils, minerals, rocks (labeled); books and journals; maps, atlases, charts; thin and polished sections; color and black-and-white slides; geologic models; equipment; and field-trip road logs.

Procedure in setting up the program will be as follows. All departments included in the *Directory of Geoscience Departments* (A.G.I. Report 11) will receive forms requesting a list of available exchange material. The information will be compiled, and duplicated lists will be distributed to all departments listed in the *Directory* and to individuals who indicate an interest in receiving them. Any department desiring listed material will get in touch directly with the department offering it. Expenses are to be absorbed by those involved in the exchange.

Requests for further information, and suggestions concerning the program, should be addressed to Professor Robert C. Ramsdell, Department of Geology, Williams College, Williamstown, Massachusetts, who will serve as "clearing house" for the program.

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The purpose of the Association, as stated in its Constitution, is "to foster improvement in the teaching of the earth sciences at all levels of formal and informal instruction, to emphasize the cultural significance of the earth sciences, and to disseminate knowledge in this field to the general public."

Anyone concerned with geological education, formal or informal and at any age level, is invited to apply for membership. *Inquiries should be addressed to the national secretary,* FREEMAN FOOTE, Williams College, Williamstown, Massachusetts.

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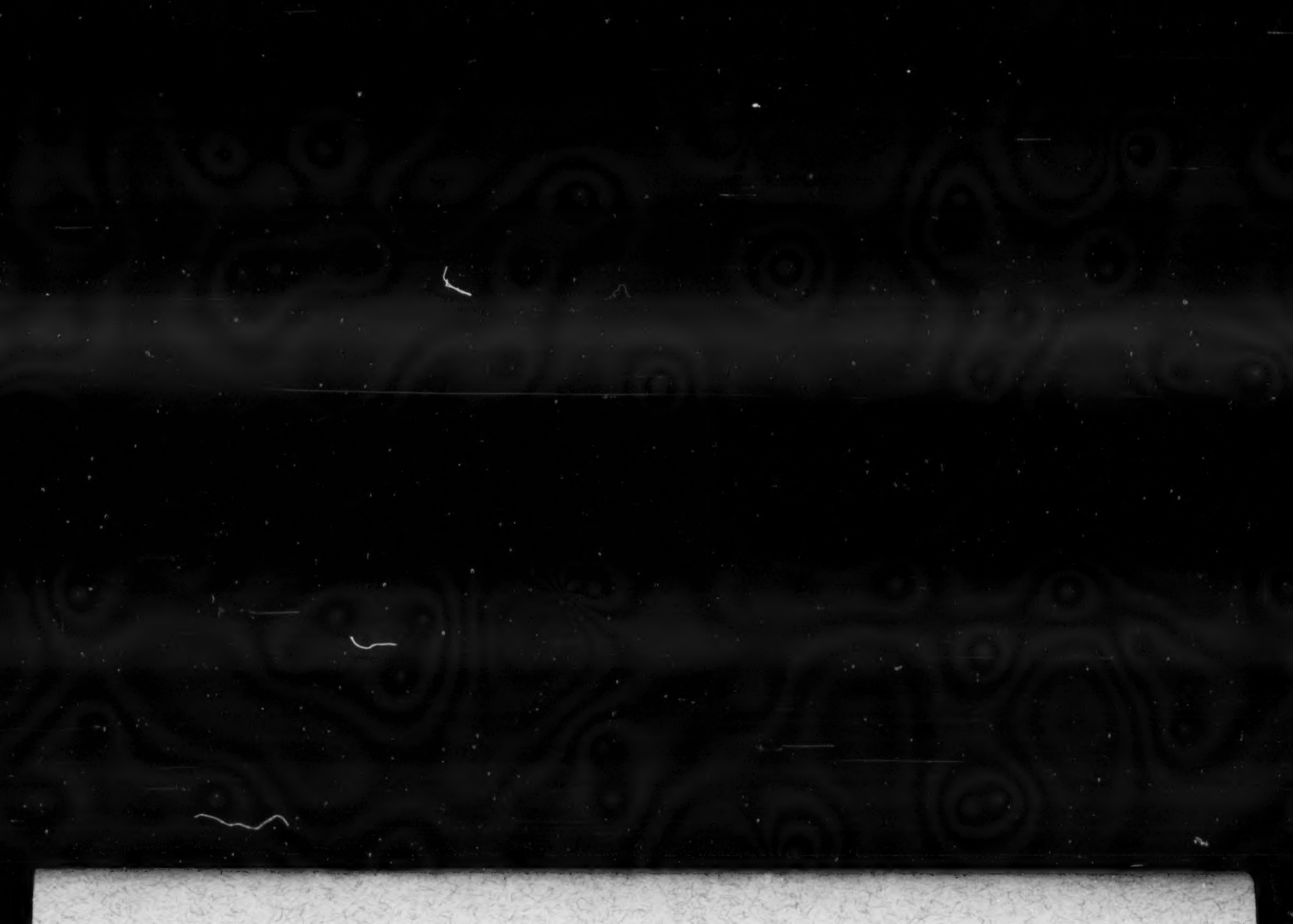
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